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Report to the Chairman, Subcommittee
on Oversight and Investigations,
Committee on Energy and Commerce,
House of Representatives

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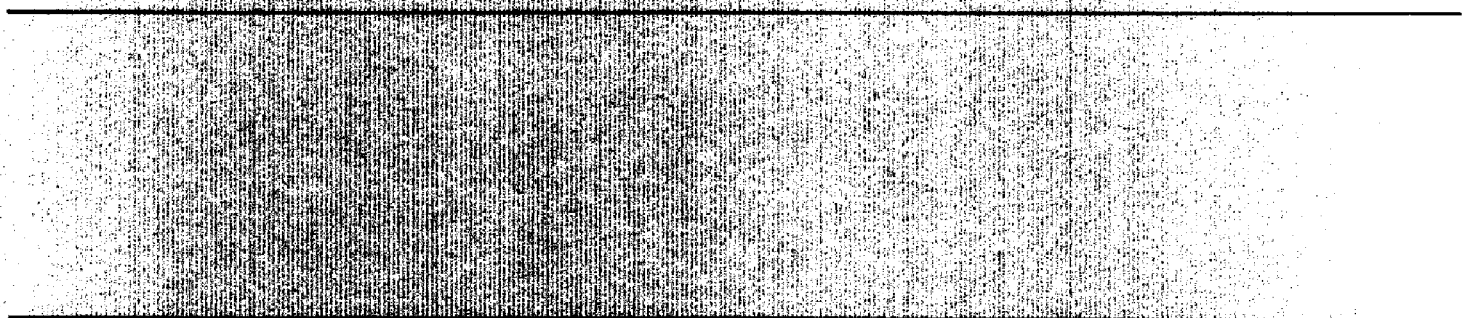
AIR POLLUTION

FAA's Reliance on Manufacturers for Jet Engine Emission Testing



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United States
General Accounting Office
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Resources, Community, and
Economic Development Division

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July 13, 1994

The Honorable John D. Dingell
Chairman, Subcommittee on Oversight
and Investigations
Committee on Energy and Commerce
House of Representatives

Dear Mr. Chairman:

Jet aircraft emit hydrocarbons, carbon monoxide, nitrogen oxides, and smoke, which contribute to air pollution. The Environmental Protection Agency (EPA) is responsible for establishing emission standards for jet aircraft engines, and the Federal Aviation Administration (FAA) is responsible for enforcing such standards. As we reported in January 1992,¹ FAA has delegated most of the responsibility for designing and conducting emission tests to jet engine manufacturers and has appointed engineers, who are employees of these companies, to represent FAA throughout the emission testing process. (Hereafter, these engineers are referred to as designees.) FAA officials recognize that, under this system, the designees serve two masters—the jet engine manufacturers who pay their salaries and FAA. Nonetheless, FAA officials emphasize that this delegation is necessary both because FAA does not have the resources to perform the emission tests and because the legal responsibility for ensuring compliance rests with the manufacturers.

Because FAA relies on the jet engine manufacturers and on its designees for emission testing, you expressed concern—in your September 11, 1992, letter and in our subsequent discussions with your office—about FAA's regulation of jet aircraft emissions. Specifically, your concern focused on (1) how FAA ensures that jet aircraft engines meet emission standards and (2) what steps FAA and the manufacturers have taken to address the potential for conflict of interest in the designee system.

Results in Brief

To ensure compliance with jet aircraft emission standards, FAA relies on manufacturers to plan, conduct, and report on the results of jet engine emission tests, and it relies on its designees to ensure that the tests are properly conducted and accurately reported. While FAA reviews and approves test plans and results, it seldom, if ever, observes the

¹Air Pollution: Global Pollution From Jet Aircraft Could Increase in the Future (GAO/RCED-92-72, Jan. 29, 1992).

manufacturers conducting such tests. FAA officials believe that because compliance with emission standards is determined by sampling exhaust emissions and performing analytical calculations, there would be little value in FAA's observing the tests conducted at the manufacturers' facilities. FAA officials explained that they periodically attend engine tests that require expert judgment to determine compliance with performance standards, such as tests for engine icing and bird ingestion. Such heavy reliance on manufacturers and designees for emission testing is consistent with FAA's policy of delegating certification responsibilities to manufacturers and designees for much of the engine and aircraft design, testing, and production processes.

Acknowledging a potential for conflict of interest in the designee system, FAA and the manufacturers have taken several steps intended to buffer designees from pressures that could compromise their oversight role. For example, FAA has a policy of appointing as designees manufacturer employees who have sufficient authority within the company to resist possible pressures to bypass FAA's requirements. Also, the manufacturers have aligned their organizational structure so that designees report to managers who are not directly responsible for designing and developing engines.

Background

FAA and EPA are responsible for regulating jet engine emissions. The Clean Air Act Amendments of 1970 directed EPA to establish aircraft emission standards and directed the Department of Transportation, which delegated the responsibility to FAA, to enforce these standards. The Federal Aviation Act of 1958 allows FAA to delegate activities, as it deems necessary, to approved employees of engine manufacturers.

Delegating responsibilities to manufacturers and designees is the backbone of FAA's operations—in all areas, not just in regulating engine emissions. For example, the Federal Aviation Act of 1958 makes FAA responsible for certifying that aircraft and engines meet FAA's standards. To accomplish this mission, FAA relies primarily on manufacturers to conduct tests and analyze data throughout the engine and aircraft design, certification, and production processes. Furthermore, throughout these processes FAA relies largely on the designees to oversee the manufacturers' activities. In 1980, a blue ribbon committee of the National Academy of Sciences found that FAA's system of delegation was sound; however, the

committee warned that FAA's oversight of the designees was becoming superficial.²

Essentially, commercial jet engines must meet two EPA emission standards: one for smoke and one for hydrocarbons.³ The first smoke standard, which took effect in 1974, was followed by more stringent smoke standards in later years. The hydrocarbon standard took effect in 1984. Although EPA once proposed setting emission standards for carbon monoxide and nitrogen oxides as well, it did not do so because it determined that such standards would not be cost-effective. Since 1984, no new jet engine emission standards have been added, and, according to EPA data, nationwide jet emissions at ground level (0 to 3,000 feet) account for less than 0.3 percent of the hydrocarbon, carbon monoxide, and nitrogen oxide emissions from all sources.

FAA regulates jet engine emissions as part of its engine certification process. This process assesses all aspects of an aircraft engine's performance and safety, including compliance with emission regulations. If an engine passes all the tests and meets all the requirements, FAA approves the engine and issues an Engine Type Certificate. The emission test is only 1 of about 80 tests that a jet engine must pass to receive a certificate. The other tests assess performance characteristics, such as the engine's ability to operate during severe weather conditions or after ingesting a bird or losing a critical part.

FAA requires manufacturers to conduct emission tests using the procedures and methods prescribed by the International Civil Aeronautics Organization (ICAO). Created in 1947 by the United Nations, ICAO has taken the lead internationally in establishing aviation guidance, coordinating international aviation issues, and setting testing standards and methods, including those for jet engine emissions. ICAO testing procedures stipulate how jet engine exhaust will be sampled and analyzed to test compliance with emission standards.

Designees are responsible for assessing whether the manufacturer's procedures and processes meet FAA's and ICAO's requirements, as well as for examining and approving certain engineering technical data. In carrying out these responsibilities, designees act as day-to-day liaisons

²Improving Aircraft Safety: FAA Certification of Commercial Passenger Aircraft, National Academy of Sciences, National Research Council, Committee of FAA Airworthiness Certification Procedures (June 1980).

³EPA also requires that a jet engine be designed so that fuel is not released when the engine is shut down. Compliance with this requirement is tested apart from compliance with emission standards.

between FAA and the manufacturer. During the initial emission testing process, designees also review the test plan, respond to questions FAA may have, and, when appropriate, recommend that FAA approve the plan.

Once FAA approves the emission test plan, designees meet with all test participants before the actual emission test to confirm the participants' understanding of the testing procedures. Designees also examine the test engine and the testing equipment to make sure that they conform to the test plan's requirements. Once this inspection for conformity is completed, designees notify FAA when the test will be conducted.

During the actual test, designees (or other manufacturer employees representing the designees) may periodically check to see that the test is being conducted as planned. After the test is completed and the manufacturer analyzes the data and writes the test report, the designees review the test report to ensure that it complies with FAA's requirements. Once satisfied, the designees send the report to FAA for its final review and approval.

FAA Relies on Manufacturers to Perform Emission Testing

FAA maintains that it does not have the test facilities or enough personnel to independently test engines for compliance with emission standards. FAA officials also emphasize that the legal responsibility for ensuring compliance with emission standards rests with the engine manufacturers.

Engine Prototypes Are Tested

Although few jet engine emission tests are conducted, the results of these tests are far reaching. A jet engine's compliance with EPA's emission standards is determined by physically testing an engine or by analyzing data from an earlier test of a similar engine. EPA does not, however, require the manufacturer to test every single jet engine that it produces for emission compliance. Rather, the manufacturer tests a prototype (or preproduction model) of the jet engine that it plans to produce. A successful test of this prototype provides the basis for FAA's certifying an unlimited number of production models of that engine design. Although production models of the engine are not tested for emission compliance, FAA managers contend that manufacturers' production quality control systems ensure that production engines meet the same emission standards as prototype engines.

Because minor changes in the design or output of an engine do not require retesting for compliance with emission standards, this one test of a prototype engine may also be used by FAA to certify the compliance of numerous other engines whose emission characteristics are similar to those of the originally tested prototype.

Because relatively few engine prototypes are physically tested, emission testing must be thoroughly conducted and its results accurately reported. Since 1984, according to FAA's estimates, 61 large domestic jet engine designs have been certified as complying with emission standards. Of these, only 12 (or an average of about 1 per year) were physically tested. Certification of the remaining 49 engine designs was based on analyses of data from the physical tests of the 12 engine prototypes.⁴

After a prototype engine is tested by the manufacturer and certified by FAA on the basis of that test, engines of that particular type can be produced in unlimited numbers, put in service, and operated without further emission testing. EPA has no in-use testing requirements. A 1979 FAA-sponsored study found that an engine, once in service, will meet emission standards as long as the engine is properly maintained. However, it is worth noting that this study was conducted on engines produced before 1979—well before the current hydrocarbon standards were established in 1984.

FAA Reviews Emission Testing Plans and Reports

Essentially, FAA has defined its role in emission testing as reviewing and approving the test plans and reports that it receives from manufacturers. When an engine prototype will be physically tested, FAA reviews the emission test plan to make sure that the manufacturer intends to follow ICAO's requirements during testing. If the test plan deviates from these requirements, FAA works with the manufacturer to ensure that the plan is revised to meet the requirements. For example, in reviewing a manufacturer's test plan, FAA recently determined that the method of sampling emissions specified in the plan did not satisfy ICAO's requirements for obtaining a representative sample of emission gases. As a result, FAA required the manufacturer to revise the planned sampling method to comply with ICAO's procedures before it would approve the plan.

Once a manufacturer completes the emission test and summarizes the results, the designee reviews the emission test report and sends it to FAA

⁴These data were provided by FAA and represent the results of testing the large domestic turbofan jet engines (rated output equal to or greater than 6,000 pounds of thrust) that FAA certified after January 1, 1984. These engines must meet the standards for both hydrocarbon and smoke emissions.

for review and approval. FAA officials told us that they compare the test report with the test plan to ensure that the test was conducted in accordance with the approved plan and that any deviations from the plan are satisfactorily explained. FAA officials also compare the test results with the emission standards. If the test report shows that the engine meets all of FAA's requirements and emission standards, FAA approves the report.

Generally, FAA staff do not attend emission tests. They believe that because compliance with emission standards is determined by sampling exhaust emissions and performing analytical calculations, there would be little value in their observing the tests conducted at the manufacturers' facilities. FAA officials explained that they have neither the necessary equipment to conduct, nor sufficient funds to attend, emission tests. Rather, FAA staff periodically attend engine tests that they believe require expert subjective judgment to determine the acceptability of the engine's performance, such as tests of engine icing, water and bird ingestion, and internal engine damage and containment. However, for emission testing, FAA officials believe that they can reasonably rely on the manufacturers and the designees to conduct proper tests.

Because emission tests are done across a broad range of operating conditions, test results must be adjusted before they can be compared with emission standards. These calculations are performed by manufacturer officials, but FAA officials do not request the raw test data or selectively test-check and confirm the reported test results. FAA officials told us that they see no need to confirm the accuracy of the computations because they believe that the manufacturers and the designees have the expertise and the integrity to ensure the validity of the test results. However, both FAA and manufacturer officials agreed that if manufacturers provided inaccurate emission test data, the inaccuracies would be difficult for FAA to detect.

FAA Relies on Manufacturers to Complete Emission Testing and Report Results

Although FAA relies heavily on manufacturers and designees to conduct valid emission tests and report accurate results, FAA does not assess the effectiveness of the controls used by manufacturers to ensure the integrity of the emission testing process. The manufacturers and designees we visited told us they take a variety of steps to ensure that the data they report to FAA are valid. For example, they told us they routinely make sure that the instruments are calibrated appropriately, that the test data are analyzed by experts, and that the test results are reviewed by various company officials as well as by the designees.

On the surface, these controls seem reasonable; however, we were unable to determine whether they were effectively implemented because no emission tests were being conducted at the time of our review. Additionally, through subsequent discussions with FAA officials in the field, we found that FAA had little knowledge of the various controls over emission testing used by each manufacturer and had never tested or assessed the operation and validity of these controls.

However, FAA headquarters officials told us that FAA staff frequently visit manufacturers' plants and observe and assess the effectiveness of manufacturers' controls over the emission testing process. FAA did not maintain records or any other evidence of such visits or the results of any evaluations of manufacturers' controls.

Oversight of Emission Testing Parallels FAA's Oversight of Other Aircraft Certification Activities

FAA's oversight of jet aircraft emission testing is similar to the agency's oversight of other aircraft certification activities. In our September 1993 report on FAA's aircraft certification program,⁶ we noted that, in response to increases in its workload, FAA had delegated most of its aircraft certification activities to manufacturers without defining or measuring an effective role for its own staff. We also pointed out that (1) FAA's diminishing, undefined role had weakened safeguards critical to a successful delegation system and (2) the agency had little assurance that its staff were effectively involved in or added value to the certification process.

To address these problems and to increase the effectiveness of FAA's system of delegation, we recommended that, among other things, the Secretary of Transportation direct FAA to (1) define a minimum effective role for the agency in its certification process by identifying critical activities requiring FAA's involvement or oversight, (2) establish guidance on the necessary level and quality of the oversight of designees, and (3) develop measures for evaluating the effectiveness of FAA staff members' involvement.

In responding to our report, FAA concurred in part with our recommendations but emphasized that it believed the delegation system was effective and that its staff were effectively involved in the certification process. After our report was issued, during a congressional hearing on FAA's role in the certification process, FAA's Associate Administrator for

⁶Aircraft Certification: New FAA Approach Needed to Meet Challenges of Advanced Technology (GAO/RCED-93-155, Sept. 16, 1993).

Regulation and Certification testified that the delegation system was effective; however, he acknowledged that FAA needed to better define and monitor its oversight role.⁶

Designee System Poses a Potential Conflict of Interest

Because FAA's designees are salaried employees of the jet engine manufacturers but must also represent FAA in overseeing the manufacturer, the designees are caught in a potential conflict of interest. Both FAA and the manufacturers acknowledge the potential for a designee to be pressured to bypass FAA's requirements, and both have taken steps to reduce the risk of such an occurrence.

FAA has a policy of selecting as designees manufacturer employees who have many years of engineering experience. Before they are selected, the designees must also have at least 1 year of experience working with FAA's regulations and interacting with the agency's staff on similar engineering projects. According to FAA officials, such employees generally have adequate technical competence, greater authority than other engineers within their company, and sufficient knowledge of FAA's operations to effectively represent FAA's position should a conflict arise.

Officials of the three jet engine manufacturers we visited also recognize that conflicts of interest could arise and have organized their reporting structures to buffer designees from such pressures. In doing so, they have placed FAA's designees off-line so that they are supervised by company officials who are not directly responsible for designing and developing jet engines. Manufacturer officials believe that this reporting structure allows the designees to represent FAA's interests more directly because the designees are not held accountable for successfully developing an engine.

Although the steps taken by FAA and manufacturers may be helpful, designees have nonetheless reported feeling pressure to compromise their FAA oversight role. As part of a 1990 Department of Transportation survey on the overall effectiveness of the designee program, 1,711 designees throughout FAA's programs were asked about pressure they might have experienced to compromise their designee role. Of the 42 designees who responded from FAA's Engine Certification Office, Engine and Propeller Directorate (the division responsible for certifying large jet engines), 9, or 21.4 percent, said that they felt limited or moderate pressure from their employers to compromise their responsibility to FAA. The remaining 33, or

⁶Aircraft Certification: FAA Can Better Meet Challenges Posed by Advances in Aircraft Technologies (GAO/T/RCED-94-53, Oct. 20, 1993).

78.6 percent, reported that they felt no pressure to compromise their responsibilities to FAA.

Conclusions

FAA relies on manufacturers and designees to plan, conduct, and report on jet engine emission tests. FAA reviews and approves emission test plans and results but does not attend tests or verify their results. Furthermore, we found no clear evidence that FAA had evaluated the effectiveness of manufacturers' controls over the testing and reporting process. FAA trusts in the integrity and honesty of the manufacturers and the designees to correctly conduct emission tests and accurately report the results.

FAA's use of designees to oversee jet engine manufacturers has a built-in potential for conflict of interest because the designees are required to oversee and approve the work of their employers. Even though FAA and the manufacturers have taken steps to avert the possibility of compromising the designees' oversight role, FAA has little knowledge of manufacturers' controls and has not assessed their effectiveness.

The issues associated with FAA's delegation and oversight of jet engine emission testing are similar to the issues we discussed in our September 1993 report on FAA's overall aircraft certification process. In that report, we noted that FAA had little assurance that its staff were effectively involved in the certification process, and we concluded that the level and quality of FAA's oversight of designees were poorly defined. Because FAA, in responding to that report, is reviewing the effectiveness of its oversight of aircraft manufacturers and their representatives, we are making no recommendations in this report.

Agency Comments

We discussed the facts contained in this report with FAA's Director of Aircraft Certification Service and made changes as appropriate. Overall, he believed that our report was factually correct but indicated that the designee system was operating effectively and needed no changes.

He also noted that under the Federal Aviation Act of 1958 and a 1984 U.S. Supreme Court decision (*U.S. v. VARIG Airlines*), manufacturers—and not FAA—are responsible for ensuring that aircraft and engines comply with EPA's and FAA's regulations. Given its limited resources, FAA must decide how and when to oversee manufacturers' testing and development activities. Moreover, the use of designees to perform this function is fully allowed by the act and is essential for FAA to carry out its role. In

performing its mission, FAA must decide how much oversight is needed. And, depending on the importance it ascribes to a test, FAA may decide that no direct oversight or verification is needed.

As you requested, we did not obtain written agency comments on a draft of this report.

Scope and Methodology

To determine how FAA enforces compliance with jet engine emission standards, we reviewed FAA's regulations and interviewed officials at the agency's headquarters and New England Regional Office. With FAA officials, we reviewed and discussed the jet engine emission standards, the testing procedures used to determine compliance with the standards, the test plans and reports, and the use of test data. In addition, we discussed FAA officials' involvement in the engine certification process. We also reviewed information and interviewed officials of other organizations involved in testing and regulating aircraft emissions, including EPA and ICAO.

Because FAA relies on manufacturers and on its designees to ensure that jet engine emissions comply with standards, we visited and interviewed three of the six domestic jet engine manufacturers: United Technologies Corporation, Pratt & Whitney Aircraft Group in Hartford, Connecticut; General Electric Aircraft Engines in Cincinnati, Ohio; and Textron Lycoming in Stratford, Connecticut. We selected Pratt & Whitney and General Electric because they produce the majority of the engines that are subject to FAA's smoke and hydrocarbon emission standards. We selected Textron Lycoming because, according to FAA, it is the only other manufacturer that produces engines subject to the smoke and hydrocarbon emission standards. At these manufacturers' facilities, we also interviewed employees who serve as FAA's designees.

In reviewing FAA's procedures for enforcing compliance with jet engine emission standards, we reviewed only the process for testing prototype (or preproduction) engines, since the tests of these engines are used to certify all engines that are subsequently produced from the prototype design. The scope of our work did not include a review of production, postproduction, or in-use engines because (1) according to an FAA study, engines, once in service, will continue to meet emission standards as long as they are properly maintained and (2) according to 1989 EPA data, nationwide jet emissions at ground level (0 to 3,000 feet) account for less than 0.3 percent

of the hydrocarbon, carbon monoxide, and nitrogen oxide emissions from all sources.

We conducted our review from April 1993 to February 1994 in accordance with generally accepted government auditing standards.

As agreed with your office, unless you publicly announce its contents earlier, we plan no further distribution of this report until 30 days from the date of this letter. At that time we will send copies to the Secretary of Transportation and the Administrators of FAA and EPA. Copies will be made available to others on request.

If you or your staff have any questions about this report, please contact me at (202) 512-6111. Other major contributors to this report are listed in appendix I.

Sincerely yours,

A handwritten signature in black ink, appearing to read 'Peter F. Guerrero', with a long horizontal flourish extending to the right.

Peter F. Guerrero
Director, Environmental Protection Issues

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THE
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DEPARTMENT OF
THE ARMY
OFFICE OF THE
CHIEF OF STAFF
WASHINGTON, D. C.

MEMORANDUM FOR THE
CHIEF OF STAFF
SUBJECT: [Illegible]

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